

Appendix K

Report on Flood Protection Measures

APPENDIX K
REPORT ON FLOOD PROTECTION MEASURES

REPORT

**REPORT ON
FLOOD PROTECTION MEASURES
AT THE
PUERTO RICO SUN OIL COMPANY
YABUCOA, PUERTO RICO**

**PREPARED BY
METCALF & EDDY DE PUERTO RICO, INC.
SAN JUAN, PUERTO RICO**

OCTOBER 1990

TO WHOM IT MAY CONCERN:

I, César M. Vincenty Pueyo, of legal age, married and resident of San Juan, Puerto Rico, hereby, CERTIFY:

1. That I am a Registered Professional Engineer duly authorized to practice my profession in the Commonwealth of Puerto Rico under License No. 7845.
2. That during October 1990, I made a visual inspections, of the existing flood protection earth dikes that surround the site where the installations of the Puerto Rico Sun Oil Company" are located, in the Municipality of Yabucoa, Puerto Rico.
3. That the purpose of said inspection was to verify if said dikes appear to be structurally sound and adequately maintained, so as to provide the protection against floods as they were built for.
4. That I have evaluated the data and have reached the conclusion that the dikes can withstand the effects of a 100-year flood event.
5. That according to information provided by Eng. Pedro Lara of the Puerto Rico Sun Oil Company, and other consultants said dikes were built prior to, or during the year 1970, following recommendations in study "Flood Control of Yabucoa Valley" performed by Tippetts-McCarthy-Stratton (TAMS), Engineers and Architects - New York - San Juan, in 1969, for the Department of Public Works of the Commonwealth of Puerto Rico. That the dikes were built using appropriate clayey soils, and that they have successfully withstood all flood events that occurred in the neighboring floodprone areas since their construction. All of which information I believe to be true and don't have any reason to believe otherwise.
6. That I did not observe any visible defects in the dikes. That they have a good grass cover, and are well maintained. Whereas, based on my experience it is my professional opinion that said dikes are structurally sound to withstand the floods for which they were built.

IN WITNESS THEREOF I hereunto set my hand and Seal on this 12 day of October, 1990, in the City of San Juan, Puerto Rico



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OBJECTIVE

The Puerto Rico Sun Oil Company is presently submitting a revised RCRA part B application for the storage of the Hazardous Waste generated at the site.

The purpose of this report is to review all the necessary data to establish the fact that the flood control and protection measures at the facility satisfy the requirements of the 40 CFR 20.14(b)(19). This analysis is made taking in consideration a 100-year storm event.

DESCRIPTION OF AREA

At present, Puerto Rico Sun Oil Company (PRSOC) operates a facility engaged in the refinement of crude oil.

The 252.25-acre Refinery complex is located east of the town of Yabucoa, and is generally bounded by PR Route 901 to the south, Puerto Yabucoa to the east, Santiago Creek to the north and private properties to west. PRSOC began operations in May of 1971 and currently processes 85,000 BPD (barrels per day) of crude oil. Major products include: kerosene, light distillates, naphtha, jet fuel, diesel fuel No. 2, No. 2 fuel oil, desulfurized gas oil, lube oil base stocks, residual fuels, aromatic extracts, slack wax and sulfur.

Figure 1 shows a regional overview of the facilities, and Figure 2 presents the location of PRSOC within the Yabucoa valley.

The topography of the Yabucoa region generally consists of mountainous terrain interspersed by broad level valleys. The area surrounding the Puerto Rico Sun Oil Company Refinery exemplifies these characteristics with mountainous terrain found north and south of the Refinery property.

Topography within the Refinery property itself ranges from near sea level in the Terminal Dock area to approximately 15 meters (50 feet) above MSL along the Refinery's border with Route 901. The area within the Refinery property generally ranges from 6-7 meters (20-23 feet) above MSL. The site itself has been leveled as part of past development actions at the Refinery.

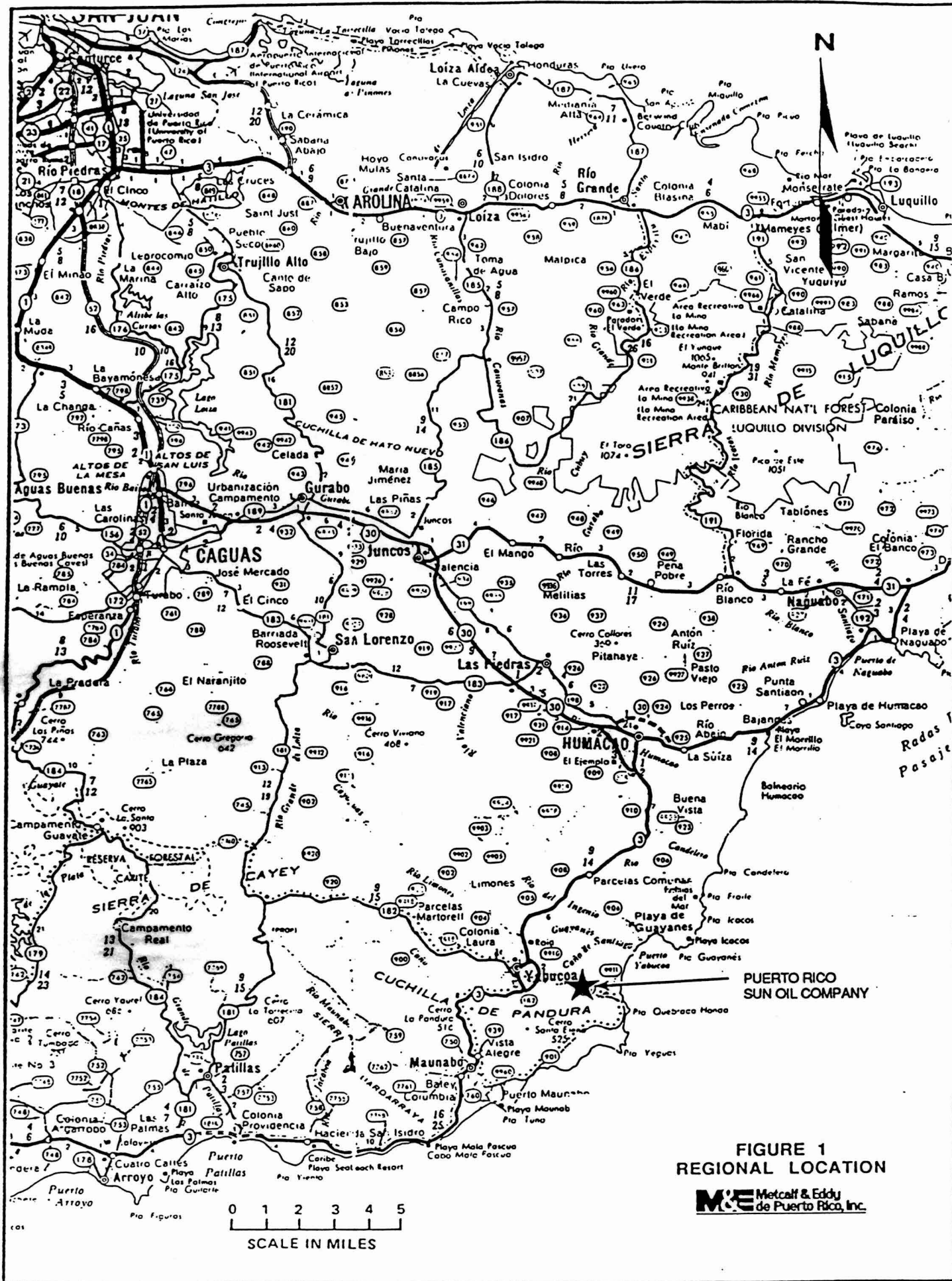
REQUIREMENTS FOR FLOOD CONTROL FACILITIES

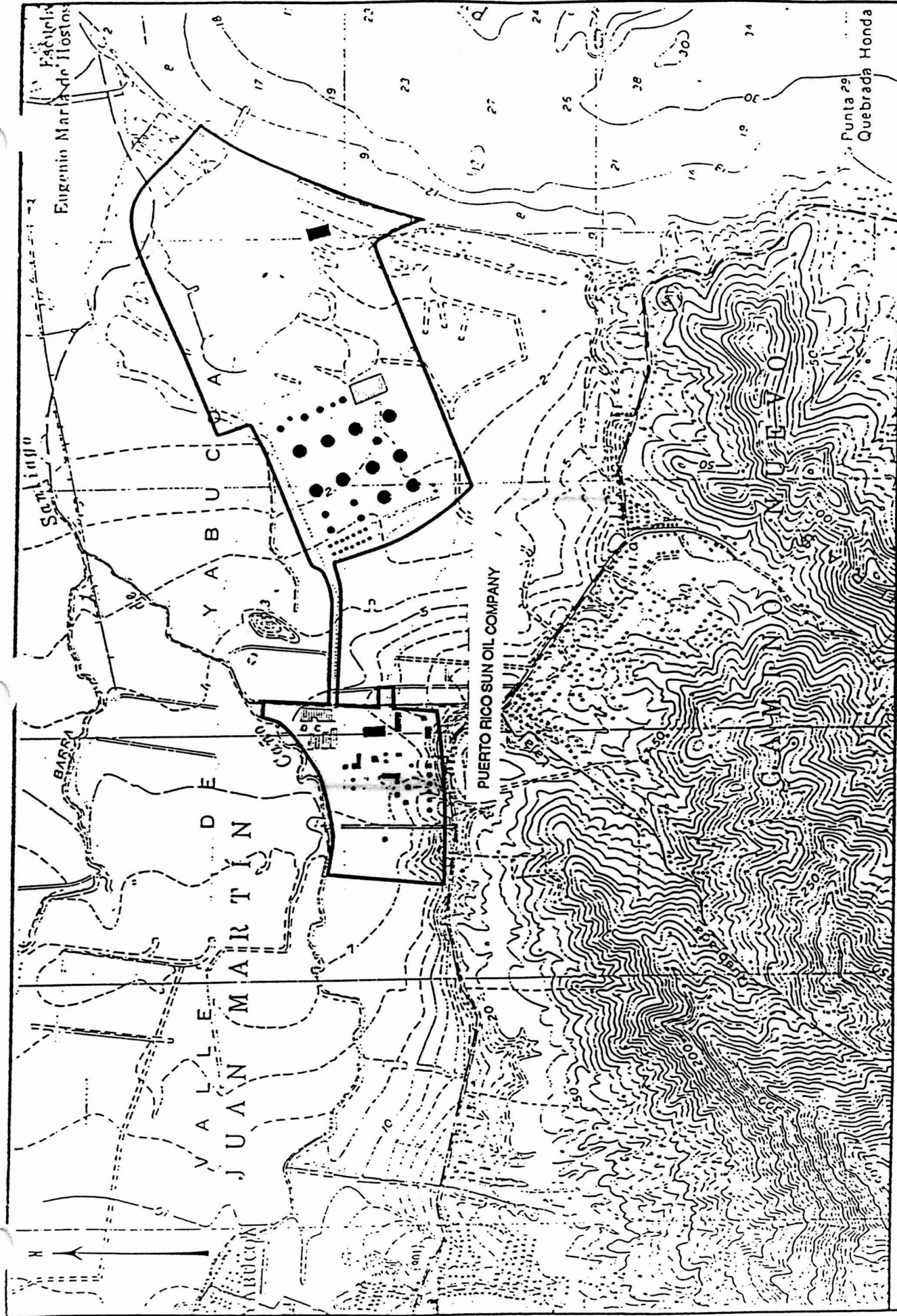
The PRSOC facilities were constructed during the period from 1969 to May 1971. Almost simultaneously an evaluation of flood control measures for the Yabucoa Valley was being prepared for the PR Department of Public Works by the Firm "TIPPETTS - ABBETT - McCARTHY - STRATTON (TAMS), with Headquarters in New York. The report titled "Flood Control of Yabucoa Valley (July 1969) is included herewith as Exhibit A.

The data, and more specifically the proposed elevations for a dike to withstand the 100-yr flood, were used to evaluate the existing control facilities at the Refinery.

The TAMS report used the September 6, 1960 flood event in Puerto Rico, as presented in the U.S. Geological Survey Circular 451, "Floods of September 6, 1960, in Eastern Puerto Rico", as the basis for the projection of their conclusions.

The data for the Yabucoa basin were extrapolated by using data from other basins with more history of rainfall and flood information, to arrive at their projections of the height of protection against the 100-yr flood.





Source: USGS Quadrangle,
Punta Guaynnes, Puerto Rico.

FIGURE 2
LOCATION MAP OF PUERTO RICO SUN OIL COMPANY

0 1000 2000
Scale in feet

The USGS published in 1971 the document "Floods in the Yabucoa Area, Puerto Rico" by Fred K. Fields stating that there were insufficient data to define the flood frequency relation for sites in the Río Guayanes basin.

In their report, TAMS contemplated three (3) stages of flood protection:

- (1) Preliminary Flood Protection (Sun Oil Co. Industrial Facilities)
- (2) Intermediate Flood Protection
- (3) Final Industrial Development and related Protection

Table 1 presents the actual and computed water surface elevations for the 1960 flood and for the 100-year flood.

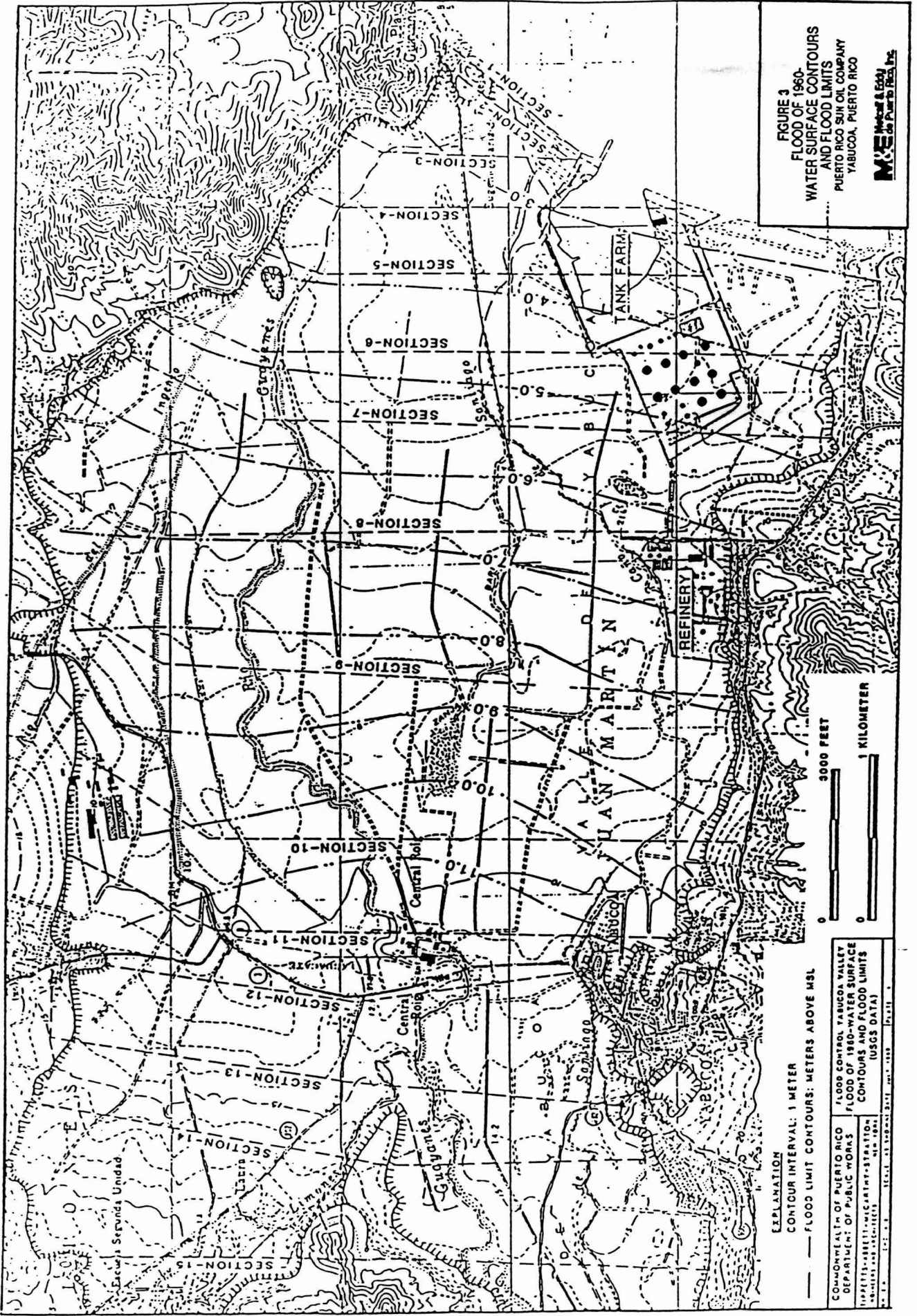
TABLE 1
(TABLE VI-1 FROM THE TAMS REPORT)
Water Surface Elevations for Present Conditions
and Preliminary Flood Protection
(mMSL)

<u>USSCS</u> <u>Section</u>	<u>Present</u> <u>Conditions,</u> <u>1960 Flood</u>	<u>Preliminary Flood Protection</u>	
		<u>1960 Flood</u>	<u>100-yr. Flood</u>
1*		1.4	1.8
2*		2.5	2.9
3*		2.7	3.1
4	3.0	3.3	3.7
5	3.8	4.1	4.6
6	4.3	4.8	5.2
7	4.7	5.1	5.5
8	6.0	6.1	6.6
9	8.3	8.1	8.4
10	10.5	10.5	10.7
11	11.8	11.9	12.1
12		14.4	
13		16.0	
14		16.8	
15		18.7	

* Adapted from USSCS topographic information.

It was established that the existing levels at the area for the industrial complex had crest elevations adequate for protection against flooding during the 100-yr. event.

Figure 3 shows a contour map of surface water elevations in the Yabucoa Valley during the extensive flooding event of September 6, 1960. The PRSOC Refinery was super-imposed on a base map taken from the TAMS report.



METEOROLOGICAL CONDITIONS

The island of Puerto Rico is located at approximately 18 degrees north latitude. It is bordered to the north by the Atlantic Ocean and to the south by the Caribbean Sea. Its subtropical latitude and proximity to water gives Puerto Rico a generally tropical maritime climate.

Local climate in the vicinity of the PRSOC Refinery is influenced by the local geography as well as the large scale climatic effects. The Refinery is located in the Yabucoa Valley, along the southeast coast of Puerto Rico. The valley is oriented NW/SE and extends 10 km (6 miles) inland from the coast. It is between 3.5 km and 6 km wide. Terrain elevation exceeds 500 meters (1,625 feet) above MSL on a hill 2.5 km (1.5 miles) to the SW of the Refinery. To the north of the Refinery terrain remains relatively flat for about 4 km (2.4 miles) than rises to about 250 meters (812 feet) above MSL 8 km (5 miles) from the Refinery. The Refinery area is 2 km (1.2 miles) from the coast, while the Tank Farm and Dock areas are located along the coast.

The typically humid air mass over Puerto Rico, land/sea breezes and orographic effects result in an annual rainfall in the Yabucoa area of approximately 60 inches. Total monthly rainfall amounts are highest from May through November. The most frequent precipitation is in the form of afternoon or evening showers, which occur throughout the year. Periods of continuous rainfall also occur due to passage of tropical storms or hurricanes or occasional cold fronts that penetrate south from the North American continent.

Local information relating air temperature, precipitation, wind, evaporation, and water temperature are gathered at a station located at Central Roig, approximately 1.5 miles from the Refinery. This station, No. 66.9829-4 is operated by the U.S. Department of Commerce's National Weather Service.

EXISTING FLOOD CONTROL FACILITIES

The entire perimeter of the PRSOC facility is protected by a perimeter levee system originally designed to protect against a 100-year flood event. These flood protection measures were taken by PRSOC during construction of the facility as part of an overall flood protection plan for the Yabucoa Valley. This levee system serves as primary protection for flooding of the plant facility in general, and additionally to protect from water damage due to wave action by dissipating wave energies. As-built details of the flood protection system are included as Exhibit B.

Since 1969, the year the PRSOC plant facility was constructed, there has never been a major flooding problem in the Refinery premises. Flood frequencies in excess of 100-years of reoccurrence interval were experienced in October 4-10, 1985 in several regions of the Island, as reported on the "Water Resources in Puerto Rico and U.S. Virgin Islands, a Review" report published by the U.S. Geological Survey, describing precipitation statistics.

Based on the available information no flooding events have occurred within the Refinery premises.

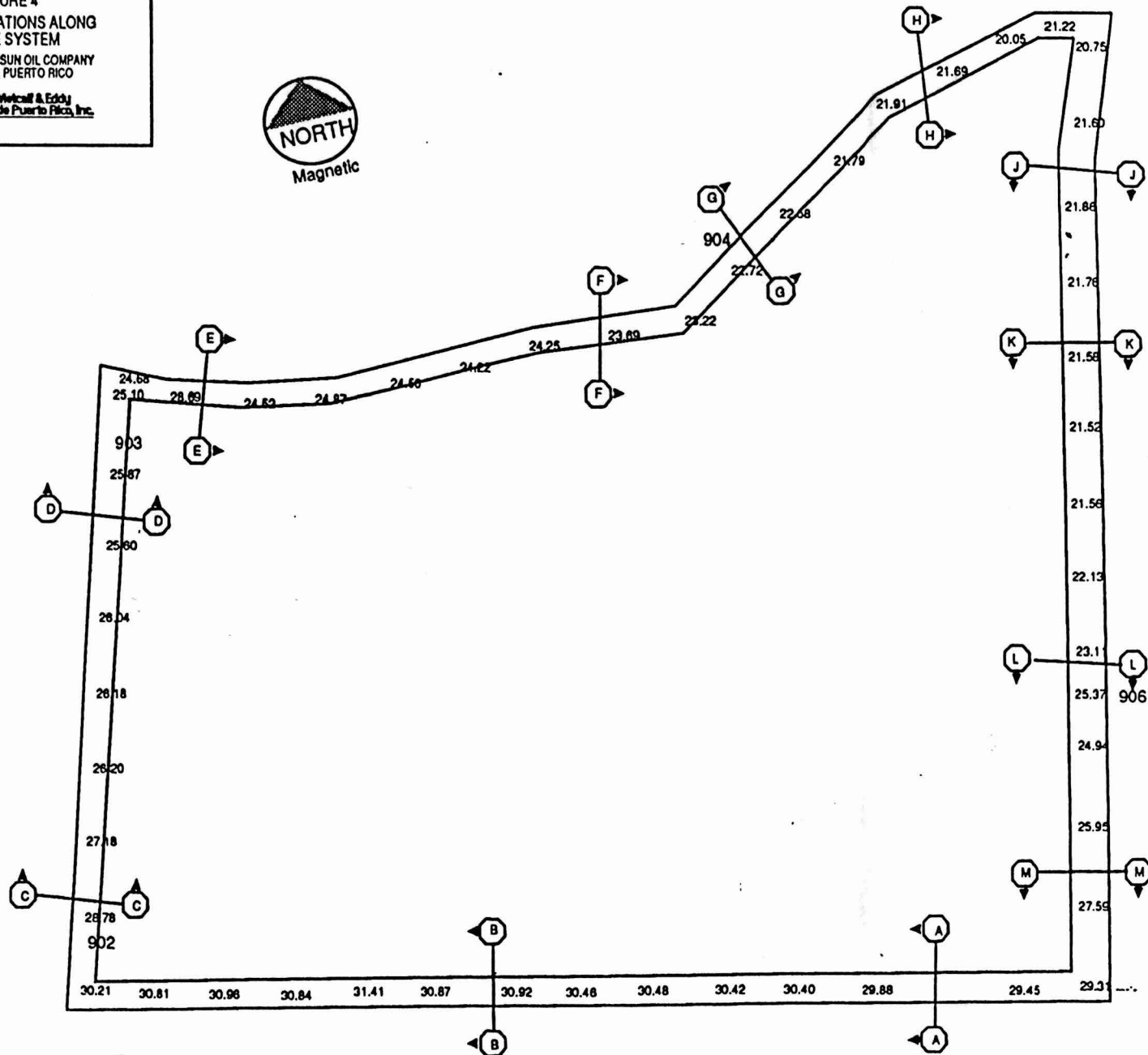
The dike around the Refinery site has elevations between 31.41 feet and 20.25 feet, as per observations made during the weeks of October 1-5 and October 7-12, 1990, by a licensed engineer/surveyor.

A reduced copy of the spot elevations observed along the levee is presented as Figure 4.

FIGURE 4
SPOT ELEVATIONS ALONG
LEVEE SYSTEM

PUERTO RICO SUN OIL COMPANY
YABUCOA, PUERTO RICO

M&E Metcalf & Eddy
de Puerto Rico, Inc.



A detailed analysis of this data, as compared with the estimated elevation of the 100-year flood event indicates that the levee would have provided sufficient protection against the 1960 rain and flooding event, using the present conditions, Table 1, adjusted to the site.

In addition, and more important, the comparison with the proposed elevation of protection against a 100-year flood event, indicated that the levee should provide protection against the referenced flood event. However, consideration should be given to the fact that the elevations indicated in the previous section are referenced to the center of the flood's cross section, where momentum and other considerations allow for increased velocities of flow and elevations of the flood water column. These conditions are not typical in the sections of the cross-section approaching the side limits. There, increased slopes in the banks, higher drag and friction effects on the water column as a result of the vegetation and other obstacles to free flow, reflect lower elevations for the level of the referenced flood. For that reason, the data from Table 1 was used, using a freeboard of 0.2m.

Therefore, using Figure 3 as a basis, and using interpolation to arrive at the revised elevations, Figure 5 was prepared. It shows that, adjusted for the actual bank conditions, the existing levee exceeds the requirements for the 100-year flood event.

DESCRIPTION OF THE LEVEE SYSTEM

The PRSOC levee system, based on a visual inspection, consists of the following:

- An outer dike which surrounds the Refinery completely to protect the facility from flood events. The dike was constructed of mostly clayey materials and is completely covered with grass which protects the dike from erosion.
- Concrete stormwater ditches along the perimeter of the Refinery's process area and inside the dike. Ditches are connected with large diameter pipes where ramps and exits are located.
- Stormwater management pond which collects all runoff water from rain events provided with a discharge pump (No. 002) to Santiago Creek to the North side of the Refinery.

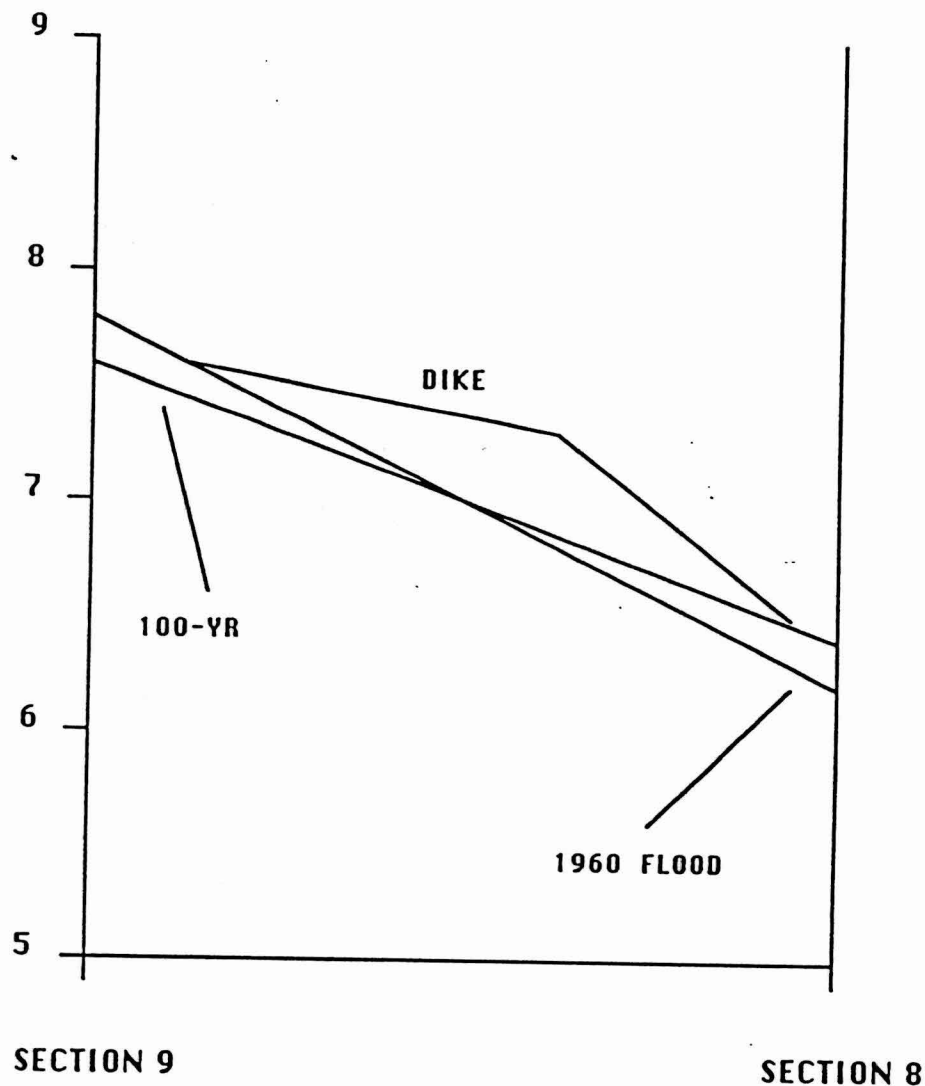
No open exits, gates or valves were observed in the dike to permit waters to drain in or out of the facility. Stormwater can only be discharged to the outside by means of the stormwater pond discharge pump (No. 002).

The average elevation of the dike is 25.22 ft. above MSL, ranging from 31.41 to 20.05 ft. above MSL.

In the main entrance of the Refinery, the dike's structure and dimensions remain unchanged and the collection ditch goes continuous underneath the entrance road.

Figure 6 shows a schematic of the collection system for contaminated and uncontaminated stormwaters.

ELEVATION
IN METERS
ABOVE MSL



NOTES:

1. ALL ELEVATIONS WERE ADJUSTED TO REFLECT CONDITIONS ADJACENT TO THE SITE.
2. THE FREEBOARD FOR THE 100 YR ELEVATIONS WAS ESTIMATED AT 0.2m.

FIGURE 5
FLOOD PROTECTION DIKE
AND 100 YR. FLOOD LEVELS
PROFILE
PUERTO RICO SUN OIL COMPANY
YABUCOA, PUERTO RICO

M&E Metcalf & Eddy
de Puerto Rico, Inc.

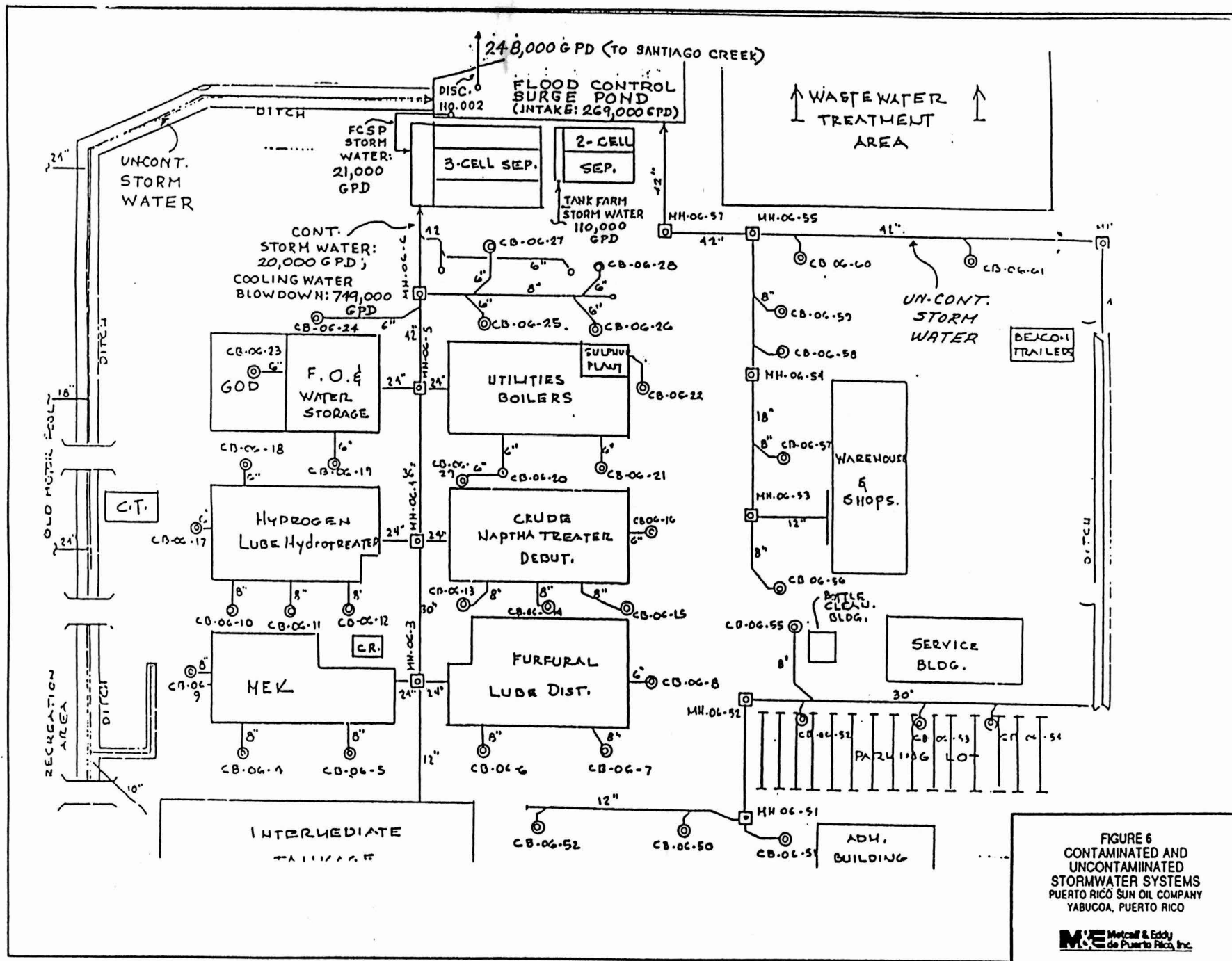


FIGURE 6
CONTAMINATED AND UNCONTAMINATED
STORMWATER SYSTEMS
PUERTO RICO SUN OIL COMPANY
YABUCOA, PUERTO RICO

MATERIALS OF CONSTRUCTION AND STABILITY

According to the tests performed on two soil borings sampled continuously and drilled in two different locations on the top of the existing dike throughout the height of the whole dike, the materials used for its construction corresponds to in-situ soils, consisting of mixtures of silty clays and/or clayey silts with variable low amounts of soil and fine gravel. These also correspond to the alluvial deposits of the Guayanes River and Santiago Creek. These natural soils are well compacted and in proper condition. The results are included in Exhibit C.

The prevailing soil properties and the vegetation present on its surface indicate that no erosion problems will arise from the velocities of a 100-year flood event, expected to be less than 3 feet per second.

From these tests it was also determined that design safety factors above 1.5 were used to consider rapid drawdown conditions during a 100-year flood event. Therefore proper structural stability is expected to prevail after this type of event.

All parameters being studied indicate that the existing levee system structures can withstand the velocity of water and will remain stable during a 100-year flood event in the area.

INSPECTION AND MAINTENANCE PROCEDURES

Objective

The Puerto Rico Sun Oil facility is located in the Río Guayanes flood plain in Yabucoa. It is subject to flood events in the basin that have the potential of disrupting the operations of the Refinery.

To reduce the potential damaging effect of that event, a levee system was constructed around the entire facility. That levee system was designed to withstand the impact of a 100-year flood event.

The purpose of this procedure is to establish an inspection program that will identify problems in the flood control system before they can be subject to failure.

Implementation

The conceptual procedure proposed herein should be reviewed and revised, if necessary, by the PROSOC staff to adapt it to the company's format and structure, and for assignment of responsibilities.

Inspection

Once a year

1. Personnel from PRSOC shall walk the entire perimeter of the facility, over the levee, and inspect the entire cross section of the levee for any indications of deterioration. Attention shall be centered on the following:
 - Abnormal growth, or abnormal lack of, vegetation in the levee sections.
 - Any signal of erosion on the sides slopes of the levee
 - Any construction, or evidence of, activities
 - Presence of debris on the side slopes
 - Presence of abnormal animal activity in the area immediately around the levee
 - Any significant, or otherwise noticeable, change in conditions as compared to original construction conditions, or the last inspection on record
2. Once the inspection is completed, a report shall be filed appropriately for record keeping purposes.
3. The report shall include, at a minimum, the following information:
 - Name of inspector
 - Date of inspection
 - Weather Conditions (at time of inspection)
 - Specific remarks on:
 - Vegetation
 - Clear Areas
 - Erosion
 - Construction Activities
 - Debris
 - Animal Activities
 - Other
 - Any other variation in conditions of property of the PRSOC Refinery.
 - Accumulation of debris on Caño Santiago, along north levee.
 - Variation in the natural course of the Caño Santiago.
4. The report shall be filed on record within 30 days of the inspection date.
5. The inspection shall be repeated whenever a storm or hurricane is reported by the appropriate agencies as imminent.
6. The inspection shall be repeated after any storm or hurricane, or large rain event resulting in a significant flood, has had an impact on the immediate area of Yabucoa.

Maintenance

As appropriate, corrective maintenance will be implemented to assure the integrity of the flood control facilities around the PRSOC Refinery.

Corrective measures shall include filling, with compatible materials, any depression, or signals of erosion on or around the levees.

Additionally it may be necessary, at times, to add energy absorbing or diffusion materials like rocks, etc., to reduce the potential for erosion on any section of the levee. In particular, it would be anticipated that the northern and eastern sections of the levee are more prone to be affected by these conditions.

STORMWATER SYSTEM COLLECTION, STORAGE REUSE AND/OR DISCHARGE FACILITIES

Consistent with an overall strategy to maximize environmental control, the PRSOC facilities segregate different waste and stormwater streams to achieve the following:

- Reduction of overall volume of contaminated water to be treated.
- Increasing the potential for water reclamation and reuse.
- Optimizing waste treatment facilities to handle specific waste streams.

Within these objectives, the storm sewer system consists of an uncontaminated, or contact-water stream.

Uncontaminated Stormwater and Flood Control System

Stormwater collected by this system is runoff from the parking lot and building area east of the process units and the open grassed area west of the process area. All of the uncontaminated stormwater flows northward by gravity in open-lined ditches and underground sewers to a 2 million gallon capacity Flood Control Surge Pond located just inside the dike along the Santiago Creek.

At the Surge Pond, an electric driven pump of 30,000 gpm, with its dedicated emergency power generating unit, lifts stormwater over the dike and into Santiago Creek to avoid flooding the Refinery premises. This discharge is designated as Outfall 002 in the PRSOC NPDES Discharge Permit. The pond and pumping facilities are designed to handle the runoff from a 10-year storm with a 3.8 inch/hour intensity. Whenever possible, the water is pumped back to the Refinery area to be used as make-up water for the cooling water system.

Contaminated Stormwater System

Contaminated stormwater is defined as rainfall which comes to contact with ground or equipment that is potentially subject to oil contamination. An underground system of catch basin and sewers receives all rainfall runoff from: (1) paved and curbed process areas; (2) maintenance aisles near the process area; and (3) Intermediate Tank Farm and similar diked area in the plant area.

Dry-weather flow in the Contaminated Stormwater System ranges from 400 to 600 gpm. These waters flow by gravity to a three-cell API Separator located in the Waste Treatment Area adjacent to

the Flood Control Surge Pond. Each cell has a maximum design capacity of 3,500 gpm of average flow. From the separator outlet, skimmed water is pumped to the equalization basin up to a maximum of 10,500 gpm.

The API Separator is constructed at an elevation such that, as the stormwater influent exceeds 10,500 gpm, the separator basins' level will rise to hold a maximum additional capacity of approximately 200,000 gallons, at a depth of 2.2 meters (7 feet) above normal operating level. At this flooded depth, the Contaminated Storm- water Sewer System can discharge a maximum of approximately 9,500 gpm excess water into the separator, greater than the capacity of the outlet pumps. This is expected to happen infrequently, once in 5-10 years, depending upon the storm intensity and duration.

Figure 6 presents a schematic drawing of the two (2) systems.

The flood control surge pond at the northern end of the site is the main component of the uncontaminated stormwater systems.

Appendix K-1

Dike Elevations and Cross Sections